

## (12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property  
Organization  
International Bureau



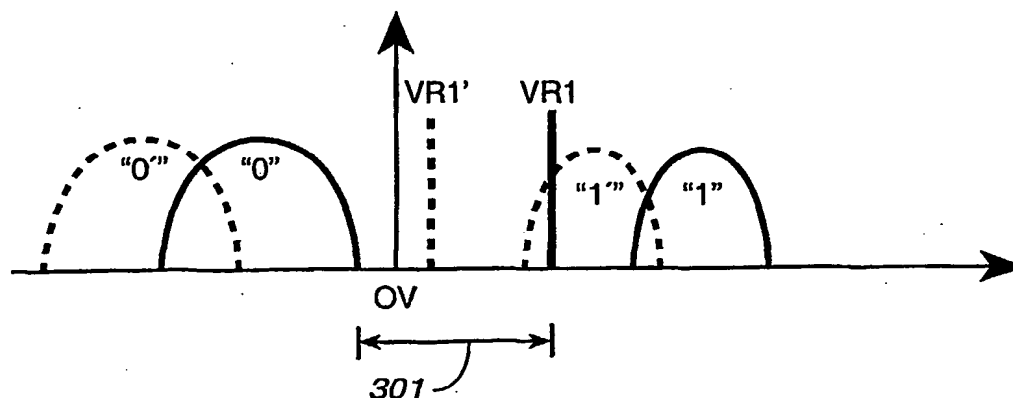
(43) International Publication Date  
28 October 2004 (28.10.2004)

PCT

(10) International Publication Number  
**WO 2004/093090 A1**

- (51) International Patent Classification<sup>7</sup>: **G11C 11/56**, 5/14, 7/06, 16/26
- (21) International Application Number: PCT/US2004/010991
- (22) International Filing Date: 8 April 2004 (08.04.2004)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data: 10/414,132 14 April 2003 (14.04.2003) US
- (71) Applicant (for all designated States except US): **SAN-DISK CORPORATION** [US/US]; 140 Caspian Court, Sunnyvale, CA 94089 (US).
- (72) Inventors; and
- (75) Inventors/Applicants (for US only): **CHEN, Jian** [US/US]; 5476 Castle Glen Avenue, San Jose, CA 95129 (US). **QUADER, Khandker, N.** [US/US]; 965 E. El Camino Real Boulevard, Sunnyvale, CA 94087 (US).
- (74) Agents: **PARSONS, Gerald, P. et al.**; Parsons Hsue & De Runtz LLP, 655 Montgomery Street, Suite 1800, San Francisco, CA 94111 (US).
- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.
- (84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).
- Published:  
— with international search report  
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: READ AND ERASE VERIFY METHODS AND CIRCUITS SUITABLE FOR LOW VOLTAGE NON-VOLATILE MEMORIES



(57) Abstract: In a non-volatile memory, the read parameter used to distinguish the data states characterized by a negative threshold voltage from the data states characterized by a positive threshold voltage is compensated for the memory's operating conditions, rather than being hardwired to ground. In an exemplary embodiment, the read parameter for the data state with the lowest threshold value above ground is temperature compensated to reflect the shifts of the storage element populations on either side of the read parameter. According to another aspect, an erase process is presented that can take advantage the operating condition compensated sensing parameter. As the sensing parameter is no longer fixed at a value corresponding to 0 volts, instead shifting according to operating conditions, a sufficient margin is provided for the various erase verify levels even at lowered operating voltages.